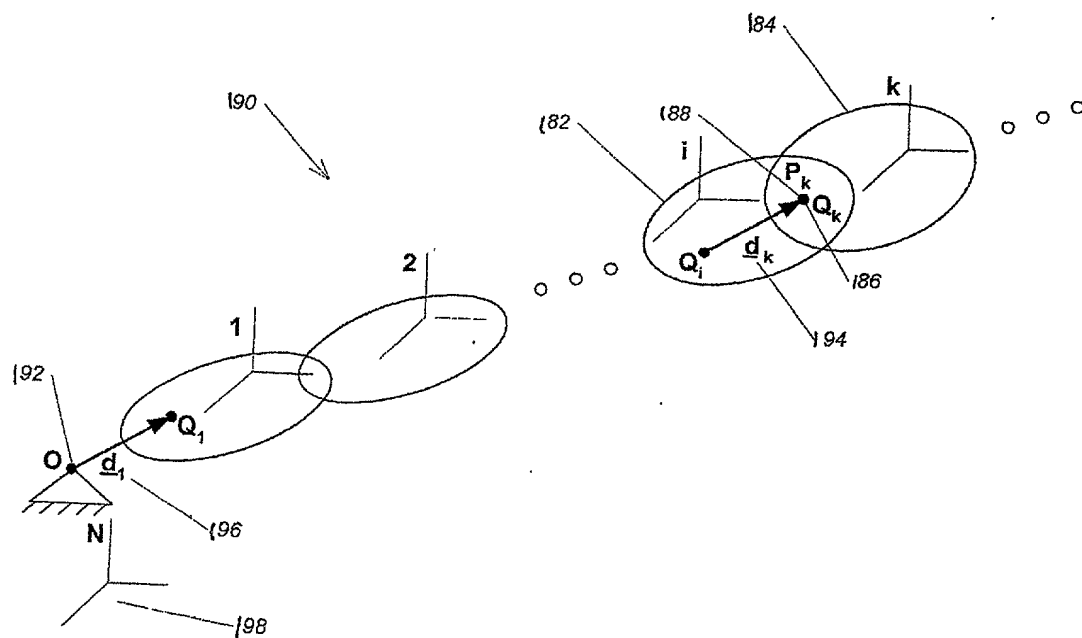
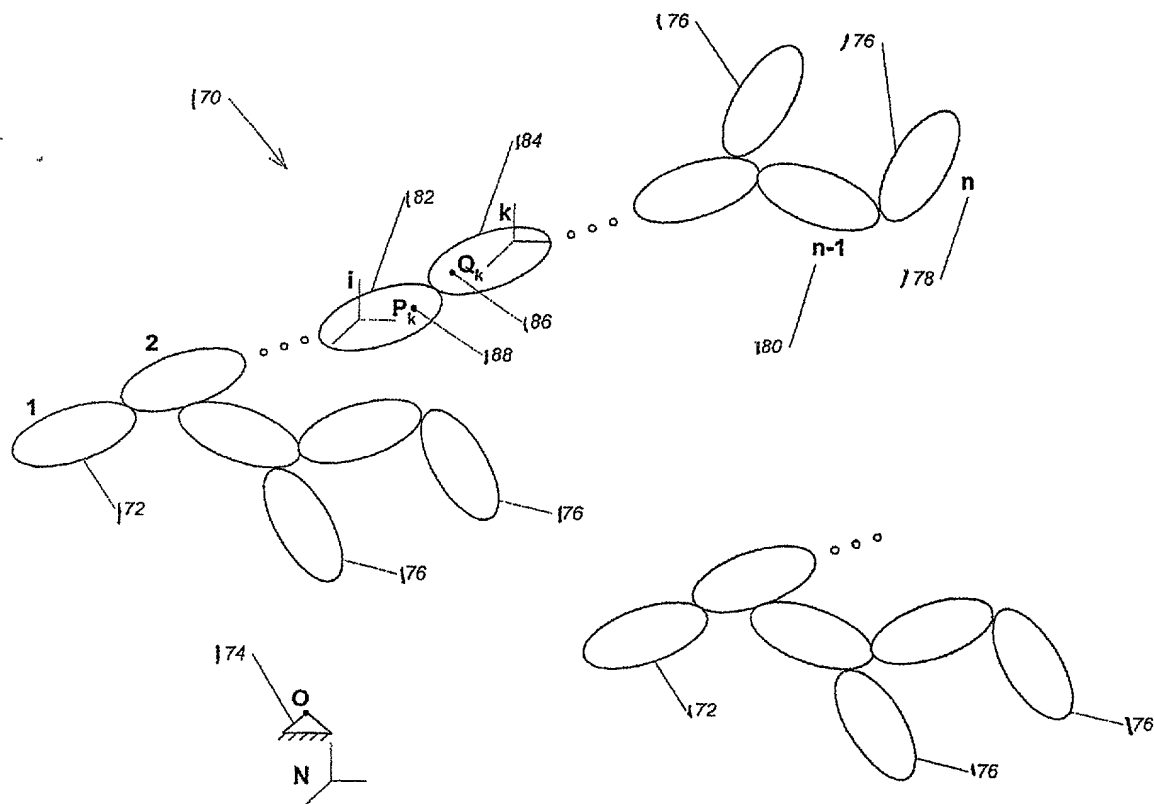
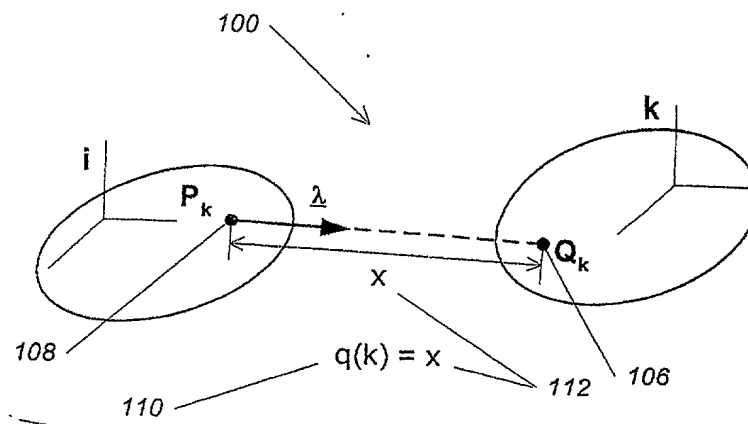


FIG. 1

Residual Form Method to compute ρ_q and ρ_u	Direct Form Method to compute \dot{q} and \dot{u}
<ol style="list-style-type: none"> 1. Compute the First Kinematics Calc. and the kinematic residual $\rho_q(k)$ 2. Generate $\hat{T}(k)$, the spatial load balance for each body 3. Compute dynamic residual $\rho_u(k)$ 	<ol style="list-style-type: none"> 1. Compute \dot{q} using joint specific routines 2. Perform First Kinematics Calc. with $\dot{u}=0$ 3. Generate residuals ρ_u and negate $\rho_u = -\rho_u$ 4. Perform Second Kinematics Calc. 5. Compute \dot{u} using Forward Dynamics

Comparison of Methods





~~Fig. 417~~

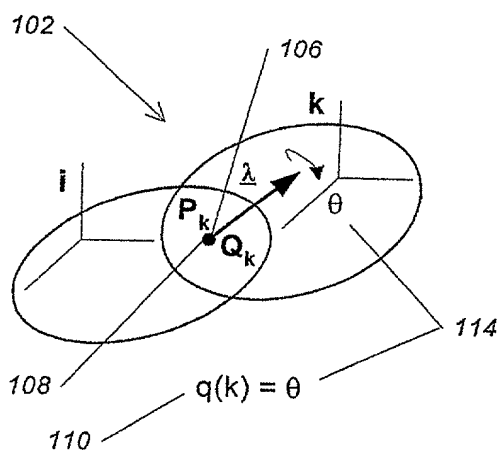


Fig. 4B

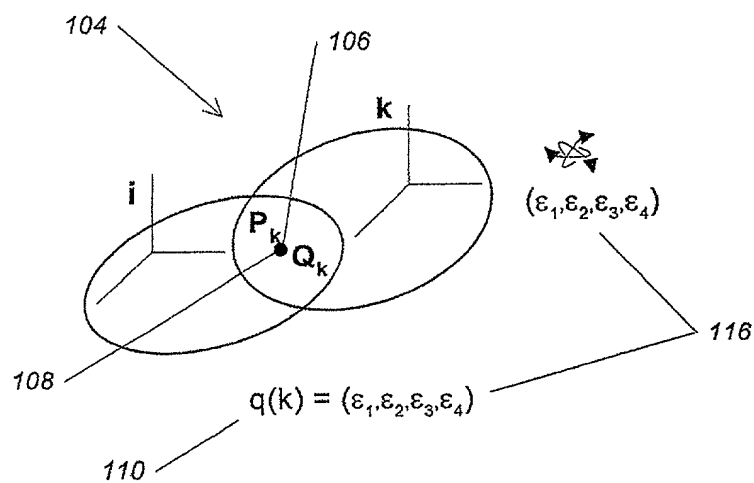


Fig. 4C

Analytic Jacobian Method

1. Compute the analytic Jacobians of the kinematics routines:

$$J_{qq} = \frac{\partial(Wu)}{\partial q} \quad \text{and} \quad J_{qu} = W$$

2. Compute $z \triangleq -M^{-1}\rho_u(q, u, 0)$ using the Direct Method

3. Compute the analytic Jacobians of the dynamics Residual routine:

$$\frac{\partial}{\partial q}\rho_u(q, u, z) \quad \text{and} \quad \frac{\partial}{\partial u}\rho_u(q, u, z).$$

4. Backsolve for the analytic Jacobian of the dynamics routine using results for z from the Second Kinematics step:

$$J_{uq} = \frac{\partial \dot{u}}{\partial q} = -M^{-1} \frac{\partial \rho_u(q, u, z)}{\partial q} \quad \text{and}$$

$$J_{uu} = \frac{\partial \dot{u}}{\partial u} = -M^{-1} \frac{\partial \rho_u(q, u, z)}{\partial u}$$

Fig. 6

